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COMMITTEE ON THE PEACEFUL USES
OF OUTER SPACE

REPORT ON THE UNITED NATIONS/ESCAP/UNDRO WORKSHOP ON THE
APPLICATIONS OF SPACE TECHNIQUES TO COMBAT NATURAL
DISASTERS, ORGANIZED IN COOPERATION WITH THE GOVERNMENT
OF CHINA

(Beijing, 23-27 September 1991)

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INTRODUCTION

A. Background and objective

1. At its thirty-seventh session, in its resolution 37/90 of 10 December 1982, the General Assembly endorsed the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82) and decided that the United Nations Programme on Space Applications should promote the dissemination of information on advanced space applications and new systems developments among managers and decision-makers, particularly for the benefit of the developing countries. At its thirty-third session, in June 1990, the Committee on the Peaceful Uses of Outer Space endorsed the United Nations Programme on Space Applications.

2. The United Nations/Economic and Social Commission for Asia and the Pacific (ESCAP)/Office of the United Nations Disaster Relief Coordinator (UNDRO) Workshop on the Applications of Space Techniques to Combat Natural Disasters was one of the activities of the Programme for 1991 as proposed by the Expert on Space Applications and recommended subsequently by the Scientific and Technical Subcommittee at its twenty-eighth session. The General Assembly, at its forty-fifth session, endorsed the activities of the Programme on Space Applications for 1991 (resolution 45/72). The Workshop was co-sponsored by the Government of China and hosted by the State Science and Technology Commission (SSTC) at Beijing from 23 to 27 September for the benefit of participants from the ESCAP region.

3. The objective of the workshop was to consider ways in which developing countries of the ESCAP region could use space techniques such as remote sensing, satellite meteorology, satellite telecommunication and satellite positioning systems to combat the rapid onset of natural disasters such as forest fires, floods, storms, winds, cyclones, earthquakes and volcanic eruptions. The workshop also discussed the need to develop ground systems and database management applications (including the use of Geographic Information Systems (GIS)) for monitoring these natural disasters as well as slow onset disasters such as desertification, erosion processes and impact of atmospheric changes.

4. The present report, which covers the background, objective, organization, observations and recommendations of the workshop as well as a summary of the lectures presented, has been prepared for the Committee on the Peaceful Uses of Outer Space and its Scientific and Technical Subcommittee. Participants will report to the appropriate authorities in their respective countries.

B. Organization and programme

5. Invitations to participate in the workshop were sent by the United Nations to professionals with responsibilities for disaster prevention and relief in their respective countries or those directly involved in such

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activities as a result of the work programmes of their institutions. The workshop was attended by 72 participants from the following Member States and organizations: Bangladesh, China, France, Indonesia, Japan, Lao People's Democratic Republic, Malaysia, Mongolia, Myanmar, Philippines, Sri Lanka, Thailand, United States of America, the European Space Agency (ESA), International Maritime Organization (IMO), ESCAP, Food and Agriculture Organization of the United Nations (FAO), United Nations Educational, Scientific and Cultural Organization (UNESCO), UNDRO and the United Nations (Outer Space Affairs Division).

6. Funds allocated by the ESCAP, UNDRO and the United Nations for the organization of the workshop were used to defray the cost of international air travel and incidental expenses of 17 participants. The Government of China, through SSTC, provided the workshop facilities, room and board for 17 participants and local transportation for the duration of the workshop and will be publishing the proceedings of the workshop.

7. Welcoming and keynote addresses were presented by Prof. Hui Yongzheng, Vice Chairman of the State Science and Technology Commission of China, Dr. Li Zengyi, Department of Disaster Relief, Ministry of Civil Affairs and Prof. Ma Junru, Director of the National Remote Sensing Centre, on behalf of the Government of China; Dr. He Changchui, Project Manager/Coordinator, Regional Remote Sensing Programme, on behalf of ESCAP; Mr. R. Garcia, Deputy Resident Representative, on behalf of the United Nations Development Programme (UNDP) Field Office in Beijing; Dr. J. C. Scott, President, Centre for Public Service Communications, on behalf of UNDRO; and Dr. A. A. Abiodun, Expert on Space Applications, on behalf of the United Nations.

8. The programme of the workshop (see the annex to the present report) was developed by the United Nations in consultation with ESCAP. The workshop was conducted through a number of plenary and working group sessions. At the latter, the participants discussed the issues associated with disaster preparedness and mitigation as well as the observations that follow.

C. Observations and recommendations of the Workshop

1. Causes of disasters

9. The critical factors that distinguish natural phenomenon from natural disasters are loss of life and property. Certainly, humans cannot prevent the occurrence of natural phenomenon, such as typhoons, hurricanes, earthquakes and volcanic eruptions - however, their disastrous effects can be lessened significantly if well conceived disaster response plans and mitigation strategies are in place prior to their occurrence.

10. As an example, deforestation caused by overlogging of indigenous trees which assist in the percolation of rainwater into the soil substrata often reduce the spongy nature of the soil, that is the ability of the soil to retain water. Thus, deforestation often results in flooding, and soil erosion

and landslides, the last two being the main causes of siltation of irrigation and hydroelectric programmes downstream and the tearing up of farmlands.

11. Misuse of the land such as (a) farming and building on steep slopes that are susceptible to landslides (b) establishment of human settlements within areas of volcanic activity, in earthquake zones and in flood plains and (c) the building of reservoirs in earthquake zones, often lead to great property loss and human suffering. Thus, many of what humans describe today as natural disasters are generally human-induced and their impact is often magnified and intensified by environment mismanagement.

2. Use of current and future space systems in disaster planning, mitigation, preparedness and relief

12. There are many uses of space systems in disaster mitigation. In considering the uses, it is important to distinguish among three types of systems: operational, experimental and future. These systems could also be categorized according to applications: Communications, Meteorology and Earth sciences. The latter categories are represented by low- and high-spatial resolution Earth observation systems. In addition, there are special geophysical satellites of importance in disaster management: satellite systems which can be used to determine the positions of Earth-based beacons or receivers, such as, Global Positioning Satellite system (GPS). All of these can be used in the pursuit of the various elements of disaster management.

(a) Disaster prevention

13. As population pressure grows due to increases or shifts in population density, increased strain is placed on the land; and humanity takes increasing chances with nature. Houses, utilities, schools and roads are placed in jeopardy of earthquakes, flooding, landslides and many other types of hazards. An important future capability for flood and landslide hazard assessment will be the digital topographic map derived at high spatial resolution by specialized satellites.

(b) Disaster preparedness and warning

14. Because of their repetitive synoptic coverage, satellites are perhaps most effective in providing essential information leading to effective disaster warnings. Archetypes of this capability are the meteorological satellites, especially geosynchronous satellites used for tracking severe storms and weather patterns. Although there are operational systems currently in use, they have limited capability. Some of the existing as well as future experimental systems permit important sea surface wind determinations, which should improve forecasting capabilities. These capabilities are, of course, related to the ability to warn of deadly storm surges. The latter is an example of one of the many areas in which theoretical and experimental space research activities are needed in order to improve our understanding of a hazardous phenomenon.

15. Meteorological satellites are also used to warn of impending disasters on land. Relatively low-resolution operational instruments provide valuable data for indirectly estimating rainfall, possible drought and locust infestations. Future satellites will provide the exciting capability to measure rainfall directly. Such data may be of use in flood forecasting and landslide warning. Experiments are currently being conducted to determine the validity of using these satellites for predicting earthquakes and forecasting volcanic eruptions.

16. Precise positioning measurements with the aid of GPS satellites can be used to measure the accumulation of regional strain, which may be a precursor to an earthquake. However, such applications are still in the research stage, as are concepts for studying thermal anomalies as earthquake precursors.

(c) Disaster relief

17. Normal ground-based communication links are very often wiped out during a disaster; accordingly, satellite-based communications can be very important. This importance has assumed even greater importance with the advent of mobile capability for voice (standard A) and data link (standard C) communications. During the relief period, such equipment can be used to transmit relief requirements and to provide medical advice to under-trained or overworked personnel on site. Such capabilities are now operational.

(d) Disaster assessment and reconstruction

18. Disaster assessment generally places exceptional requirements on a satellite system: it must respond very quickly. Optical sensor systems cannot guarantee the availability of images of a flooded area because such areas are likely to be cloud-covered immediately after a flood. The launch of research satellites with synthetic aperture radar (SAR) in the recent past, and their attainment of operational status in the near future, will alleviate such problems. The recent eruption of Mt. Pinatubo in the Philippines has demonstrated that the frequencies of Earth observation by satellite can provide useful information on volcanic ash fall cover. Similar studies have also shown that such data can be useful in observing forest damage due to severe storms.

Recommendations

19. One key to avoiding such disasters is hazard assessment, most often in the form of a vulnerability map. Perhaps the most important component of the vulnerability map which space technology can provide is the land use or land cover map. These can show the location of cultural concentrations, such as houses, relative to earthquake zones (seen as lineaments), flood plains and landslide hazard areas. Such data are available operationally through Landsat and Spot programmes. Because of the resources needed to use these data, it is important for the users to know whether the operators of a space segment are committed to providing the data on a continued operational basis.

(e) Communication systems for disaster mitigation

20. Traditional terrestrial telecommunications - particularly in remote areas of disaster-prone countries - have been costly to install, difficult to repair and vulnerable. Accordingly, such systems have been virtually useless in areas where geography or climate inhibited their installation and maintenance, and thus have been of limited value to disaster managers. Fixed Satellite Services provide a variety of applications for disaster management but they, too, have limitations. Because of their need for large-size receiving and transmitting antennas (and associated high-power requirements), quick response to areas of the world that are difficult to access remains a significant limitation to effective disaster response. However, with recent developments of Very Small Aperture Terminals (VSATs), Ultra Small Aperture Terminals (USATs), and phased array antennas, Fixed Satellite Service will likely be of greater use in disaster management.

21. One of the most recent and dynamic communications technologies available to disaster managers is mobile service by satellites. This low-cost communication capability has proved, even in the relatively short time of its commercial availability, that it can offer dramatic results in relief efforts which have not been possible before. Furthermore, as a complement to remote sensing technology, mobile service has the capability to dramatically improve risk assessment, disaster preparedness, early warning and onset and post-disaster relief operations. This service is now available to areas previously considered inaccessible because of their location, terrain, weather or demography.

22. Although various international institutions and individual countries have filed, or indicated their intention to file, for mobile satellite orbital slots, these services will likely be available only on a national or regional basis. However, it is not certain that they will be inter-operable, that is, they may not be able to operate at the same frequencies, thus limiting communication between and among systems.

23. There is, however, a mobile satellite service that is currently available throughout the world and is operated by the International Maritime Satellite Organization (INMARSAT). The participants recognized the commitment of INMARSAT to develop services that are responsive to the needs of the disaster management community, further recognized INMARSAT's generosity in granting a free space segment during catastrophic disasters and noted the additional support of many signatory countries that have offered free use of their coastal Earth stations. The need to incorporate this type of communications resource into disaster planning and response was recognized by the participants. Additional needs were also discussed, as described below.

24. On a national level, the need exists to reduce the vulnerability of existing telecommunications systems; to ensure that future terrestrial and fixed satellite infrastructure is planned and constructed taking into account the particular types of disasters that are common to that country; and to augment these systems with portable, easy-to-operate mobile satellite equipment.

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25. From the international point of view, countries respond to human needs that arise from catastrophic disasters. Addressing these needs on an international level requires the development of agreements that would facilitate such international response efforts and the entry and exit as well as the operation of communications equipment by relief workers in affected areas. In this respect, UNDRO's current initiative for facilitating international consideration of a formal convention on disaster communications was recognized.

3. Factors influencing effective use of space techniques

26. These factors include:

- (a) Capability and availability of technology;
- (b) Affordability of technology, relative to the intended application and other possible options that might accomplish similar objectives;
- (c) National and international regulations that encourage or inhibit effective applications of technologies;
- (d) Institutional relationships and protocols required to facilitate optimal use of technologies by all users;
- (e) National and international political issues that may have a negative impact on the acquisition and application of technology;
- (f) The requirement to include disaster management experts in the process of planning for technology development and application;
- (g) The need to develop training programmes in the application of existing technologies and education programmes that could lead to the development of indigenous capability and frequent applications of technologies;
- (h) The need to undertake and support research in the development of ground systems and data management applications, including GIS, as a complement to development of space hardware.

27. The workshop also noted that FAO had made considerable advances in the operational use of satellite remote sensing techniques for monitoring key environmental parameters, such as precipitation and vegetation biomass cover, which are relevant to disaster prevention in relation to droughts, flooding, insect pests and longer-term environmental degradation. Furthermore, the meeting noted that FAO, in close cooperation with the European Space Agency, was developing satellite communication capabilities which in the near future could provide an effective means for large-volume data and information exchange on a real-time basis at a regional level.

28. GIS is a very powerful tool for the handling of remote sensing data and for the overlaying of such data with other types of digitized thematic information such as topographic, geologic, vegetation and population density maps. The development of very powerful PC-based and user-friendly GISs has facilitated image processing and geometric and scale correction procedures which are necessary for the production of different layers of precisely matching maps.

29. Current developments threaten to cause a "knowledge gap" between those who can use remote sensing and GIS and those who cannot. The gap is more apparent between older and younger professionals than it is between developing and industrialized countries. The application of remote sensing techniques and GIS can lead to the best possible results only when used by specialists with a great amount of conventional experience in the field of applications, such as meteorologists and earth scientists; these specialists are able to bring their wealth of experience to bear on the analysis being made.

Recommendations

30. In order to improve national and regional forecasting capabilities for environmental monitoring, with specific reference to drought and flood forecasting, it is recommended that the countries of the ESCAP region, as much as possible through the mechanisms of the ESCAP Regional Remote Sensing Programme, work closely with FAO for the transfer of ARTEMIS and DIANA technology to the region, taking into account the existing facilities for satellite data acquisition and processing.

31. Remote sensing and GIS should not only be taught at the university level, but should also be introduced into the curricula of short-term training courses for mid-career professionals. In this connection, training packages should be developed for hands-on experience in the collection and management of remote sensing and Geographic Information Systems.

4. Combating disasters in the ESCAP region

(a) Observations

32. The Workshop noted that the ESCAP region is very prone to disasters. Among these were the catastrophic cyclone and tidal surges that hit Bangladesh in May, the Mt. Pinatubo volcanic eruption in the Philippines in June and the devastating floods in China in July, just to name a few that have already occurred during 1991. Atmospheric phenomena such as typhoons and tropical cyclones, geological phenomena such as earthquakes, and volcanic eruptions are of great concern in the ESCAP region.

33. Many countries of the region have come to appreciate the growing importance of using space technology to combat natural disasters with the aid of satellite systems such as ALMAZ, ERS-1, INSAT, METEOR, METEOSAT, MOS, LANDSAT, SPOT, NOAA, GMS and GPS; these systems are used in conjunction with

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ground-based and serial systems. However, a number of limiting factors, including the cost of data, hinder the full utilization of these capabilities.

(b) Recommendations emanating from lessons learned

34. It was recommended that Member States address themselves to the following needs:

- (1) In-depth education and research;
- (2) Early dissemination of warning;
- (3) Establishment of policies against illegal logging and adoption of rational logging policies;
- (4) Coastal zone monitoring;
- (5) Constant monitoring of forest fires;
- (6) Gaining the confidence of the public through accurate weather forecasting;
- (7) Regular weather information over the airwaves and on site;
- (8) Building of dykes and other structures to control lava flow from volcanic eruptions;
- (9) Use of GPS system for detecting frequent motions of tectonic plates.

5. Essential national steps, and mechanisms for promoting regional and international cooperation

(a) National

35. The essential steps and mechanisms at the national level include:

- (1) Updating of equipment for data reception and disaster warning systems;
- (2) Establishment of contact points in each country for disaster mitigation purposes and for the inventory of telecommunications and remote sensing facilities that may be available for disaster management;
- (3) Formulation of disaster mitigation policies and development of programmes of action, including coordination of activities with relevant national entities;
- (4) Re-establishment of communication links which should be more resilient and better able to withstand future disasters.

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36. Until recently, mobilization for preparedness has been largely a public sector affair with local authorities bearing the burden of plan formulation, financing and strategy execution. But pre-disaster plans can only be effective if disaster-prone countries are able to incorporate such plans into their programmes and implement them as part of a regular institutional process. National and community capabilities are limited, particularly in the developing countries, where the capacities of the national infrastructure are often strained to manage even the most basic of social and economic development programmes.

37. In order to reduce this reliance on an overtaxed public-sector competence, and recognizing the need to generate local capacity to prevent and prepare for disasters, more attention should be given to attracting into prevention, mitigation and preparedness planning and operations entities outside the government structure such as local businesses, trade groups, voluntary organizations and community leaders. The business community in particular, with its financial, technological and logistical capabilities, should be regarded as a valuable partner in the planning process and a resource which should not be ignored.

(b) Regional

38. At the regional level the workshop noted the need for:

- (1) Exchange of information within the ESCAP region;
- (2) Joint active management of river basins among Member States that share the same catchment with a view to prevent and mitigate potential disasters;
- (3) Establishment of regional understandings for development of strong relationships between regional communication communities and disaster communities. In this connection, the use of regional communication systems (e.g. Palapa and Asia-Sat) to share programmes and information should be fully encouraged;
- (4) Continuation of the current mandatory practice of distributing processed data from its GMS meteorological satellite by Japan.

39. The workshop noted the catalytic and direct role of the ESCAP/UNDP Regional Remote Sensing Programme (RRSP) in promoting remote sensing development and applications in the ESCAP region. The workshop recommended that ESCAP/UNDP RRSP should continue to provide technical assistance to its member countries, through its established networks, with emphasis on organizing training and education activities, pilot projects and information services, including the use of remote sensing technology to combat natural disasters.

(c) International

40. The workshop noted that at present, there is no globally coordinated observational satellite system that could provide daily observations for coping with fast transient environmental phenomena. The workshop also noted that in this connection the Society of Japanese Aerospace Companies (SJAC) is proposing the development of such a system, to be known as the World Environment and Disaster and Observation Satellite System (WEDOS), in collaboration with the Government of Japan and other space agencies around the world. WEDOS is a constellation of 38 combined polar and geostationary satellites. SJAC hopes that WEDOS could eventually be an effective and realistic disaster mitigating space system, and that it could be developed and managed through the United Nations.

SUMMARY OF PRESENTATIONS

A. Overview of satellite technology usage
in disaster management

41. Over recent years a number of major disasters - of natural, technological or ecological origin - have made the international community dramatically aware of the immense loss of human life and economic resources caused regularly by such calamities. Based on the recognition of the devastating impact of disasters on socio-economic systems as a whole, with the beginning of the 1990s the international community has embarked on a major, visionary initiative, the International Decade for Natural Disaster Reduction (IDNDR).

42. With regard to space technology, IDNDR does more than simply educate the disaster management community in the simple uses of the technology. It promotes a recognition that the national infrastructures that make possible these applications must be encouraged and supported in their mission and adequately protected against disasters themselves. Disaster prevention, preparedness and relief operations can benefit from existing as well as new space technologies.

43. Satellite technology can make substantial contributions in each of the three phases of disaster management: preparedness, prevention and relief. Various kinds of satellites, especially communications, meteorology, remote sensing and geophysical satellites, are or may become useful tools in the above phases. Though much of this technological capacity has been in existence for more than a decade, operational capabilities are currently provided only for storm warnings and search-and-rescue activities.

44. Since the forecasting of natural hazards relies on either mathematical models or the empirical understanding of physical phenomena, the ability to improve, update and build on these observations is critical. New knowledge gained over the past decade is fundamentally changing the way we perceive the Earth and its components. Recent space science technology has also created a dramatic leap in the ability to measure and learn about the physical, chemical

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and biological interactions of the Earth's magnetosphere, atmosphere, oceans and land areas and to assess the importance of these interactions to global, physical and biogeochemical processes.

45. The main aspects to be considered in natural disaster mitigation are: (a) accurate prediction of the event that may cause or contribute to the cause of a disaster; and (b) a rapid assessment of the location and extent of damage and an evaluation of the potential for further damage (such as earthquake aftershock, mud slides, storm surges).

46. Improvement in prediction must be based mainly on an improved knowledge of the causes and mechanisms of a disaster (e.g., improvement of meteorological forecasting, medium- and long-term climate changes, plate motion as driving mechanism for earthquake and volcanic activity), while evaluation of disasters must be based on the improvement of Earth observation systems, which must become more independent of weather and sunlight conditions.

47. However, weather forecasting nowadays is severely limited by the lack of accurate information on wind and wave speed and direction over a large part of the ocean, mainly in the southern hemisphere. Also, the lack of precise altimetric and geodetic measurements over long periods is a constraint to plate motion models development on a human time scale. A large part of the rain forest over the Earth's surface is poorly mapped and deforestation of those areas can scarcely be measured by conventional systems. Disasters caused by rainstorms and flooding are difficultly measurable with conventional optical sensors.

B. Communications satellites and disaster mitigation

48. Satellite communication systems offer an important potential for real-time dissemination of disaster information. Early warning and quick re-establishment of communications are vital to mitigation and relief operations for all rapid-onset hazards, such as earthquakes, floods, landslides, hurricanes, tsunamis, volcanic eruptions and wildfires. When natural disasters strike, the survival of the local population may well depend upon the contingency planning and preparation that is already in place, as relief may be hours or days in arriving. All too often, local telecommunications networks are destroyed by disasters. When this happens, it is not likely that vital services can be reconstituted in the crucial early hours of the response phase.

49. There are satellite solutions which can provide reliable, instantaneous and simple-to-use communication with the outside world. New low-cost mobile communications by satellite can play a major role in reducing the devastating effects of natural disasters and will complement and enhance existing terrestrial and fixed satellite services. They dramatically improve hazard prediction, risk assessment, disaster preparedness, early warning and onset and post-disaster relief operations. This service is now available to areas previously considered impractical or impossible to cover because of their location, terrain, weather or demography.

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50. Mobile satellite communications can be used by land, aeronautical and maritime transportation industries, so that disruption of distribution networks of food, water and essential medicaments due to disasters will be reduced. This also should enable a reduction in response time to medical emergencies and enhance the ability to stabilize patients "on the scene". Further, epidemiological information, disease registries and blood bank and medicine inventories could be communicated more rapidly.

C. Meteorological satellites

51. Meteorological satellites can continuously monitor the atmosphere from space. Cloud maps, atmospheric temperature, humidity, wind, radiation, precipitation distribution and other information derived from a meteorological satellite's payload have the advantage of simplicity.

52. Synoptic observations of meteorological satellites of regional cloud distribution, nearly in real time from geosynchronous orbit, have become an important element in weather forecasting. Advanced techniques for determining cloud-top heights and wind fields are less well known but at least as important. Several types of polar-orbiting meteorological satellites have also been launched. As in the case of geosynchronous satellites, these are expected to be a continuous source of environmental data and should be considered operational.

D. Remote-sensing satellites

53. Remote-sensing satellites are used to observe, map and monitor features and phenomena on the Earth's surface. They are distinguished from meteorological satellites by their finer spatial resolution capability. Such satellites orbit the Earth around its poles. For technical reasons (e.g., limitations on the rate at which data can be transmitted to Earth), these satellites' total field of view is limited to a swath several hundred kilometres wide, thus limiting the amount of the globe they can observe in a day. Such satellites are of potential interest and use to the disaster-mitigation community.

54. Considering the potential of remote-sensing systems for disaster management application, it is important to realize their restrictions. Three parameters of such systems which are ultimately related are the spatial, radiometric and spectral resolution. If the spatial resolution is improved, the radiometric and spectral resolution will be decreased. The spectral resolution can be improved by lowering the orbit of the spacecraft, thus decreasing the width of the swath. This results in lower frequency of observation.

55. Frequency of observation, a critical factor in terms of sudden disasters, may be considered as the satellite's "temporal resolution". The rigidity of orbital mechanics and optical system costs place considerable constraints upon

the most desirable spacecraft characteristics for response to sudden disasters: radiometric, spatial and temporal resolution. For the time being, the optimal instrument appears to be a pointable imager that sacrifices spectral capability for spatial (and/or temporal) resolution. Some improvements would be achieved by flying such an instrument in a low-inclination orbit.

56. Another important factor to be considered is cloud cover, which is responsible for the loss of approximately half the opportunities for observing the Earth. Instruments sensitive to microwaves can avoid this problem owing to the fact that they can penetrate through clouds. While their capacity for spectral discrimination is limited, they can obtain good radiometric resolution. High spatial resolution may be achieved using the synthetic aperture technique, which involves correlating the signal from several points along the spacecraft's orbit.

E. Existing systems

57. Today, the Earth is encircled at the equator by a set of geostationary meteorological satellites and low-altitude polar-orbiting satellites. Further, geosynchronous communication satellite systems serve various national and regional needs throughout the world. Only two of the remote-sensing satellite systems can currently be considered operational from the point of view of sufficiently quick response: LANDSAT and SPOT.

58. The INMARSAT global mobile satellite communications system is ideally suited to supporting disaster preparedness and relief operations throughout the world. The system provides high-quality, reliable communications services through small, highly mobile terminal equipment. The INMARSAT system matches the specifications for a disaster communications network: it is independent of local telecommunications infrastructures, is not prone to single point failure, provides unlimited communications, is compatible with other INMARSAT users, simple to operate, flexible, portable and reliable.

59. Another international satellite system for search and rescue consisting of a constellation of polar-orbiting satellites and a network of Earth stations is COSPAS-SARSAT. It provides distress alert and location information to appropriate rescue authorities anywhere in the world for maritime, aviation and land users in distress. Monitoring the Doppler shift in reception from a transmitting distress beacon as the satellite passes over the beacon allows rescue teams to obtain a directional reference on the beacon's location. Another satellite passing from a different direction can provide another directional reference at the intersection of the vectors.

60. Launched successfully by the European Space Agency on 17 July 1991 into a polar orbit with mean altitude of 780 km, the Earth Resources Satellite ERS-1 represents a new generation of remote-sensing satellites. It uses advanced active microwave techniques to make global measurements and imaging regardless of cloud and sunlight conditions. It also measures many parameters not

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covered by existing remote-sensing satellite systems (LANDSAT, SPOT, ALMAZ, PRIRODA), including those of sea state, sea surface winds, ocean circulation, sea and ocean levels, as well as all-weather imaging of ocean, ice and land. Data will be collected from remote areas such as the polar regions and the southern oceans, from which there has been no information so far.

61. To implement these tasks, ERS-1 carries on board a set of active microwave sensors which allow collection at all weather conditions of global geophysical information over the oceans as well as high-resolution imaging of coastal and land areas. The ERS-1 mission will provide data contributing to (a) improved understanding of ocean-atmosphere interaction in climate models; (b) major advances in our knowledge of ocean circulation and the transfer of energy; (c) more reliable estimates of the mass balance of ocean ice sheets; (d) better monitoring of dynamic coastal processes and pollution; and (e) improved detection and management of the land-use changes and cover.

F. Future systems

62. A concept of the World Environment and Disaster Observation System (WEDOS) using a space segment has been proposed by the Society of Japanese Aerospace Companies in collaboration with the Government of Japan. The purpose of this system is to implement global-scale around-the-clock monitoring of the Earth environment and observation of natural disasters by the space segment consisting of 26 Earth observation satellites to be launched into medium-altitude orbit.

G. Application of satellite technology to combat natural disasters - case histories

63. Floods, cyclones and other disasters are common phenomena in Bangladesh every year. Following upon the catastrophic floods of 1987 and 1988 and the severe cyclone of April 1991, the Government of Bangladesh has sought anew to improve its disaster management. Since almost all the rivers of Bangladesh have their headwaters outside the country, regional cooperation and exchange of hydrometeorological data among the neighbouring countries are of extreme importance for an improved disaster preparedness programme.

64. In November 1988, heavy rains and devastating floods occurred in southern Thailand, causing an estimated damage of about US\$ 300 million and the loss of more than 400 human lives. GMS-3 satellite images were used to indicate heavy rain areas. Two days before the events and two days afterwards data sets from LANDSAT and SPOT satellites were selected to analyse flood damage. Based on the analysis, 3 per cent of the forest area was converted to agricultural use, especially for rubber plantations or orchards, and 11 per cent of the area was registered as having experienced landslides. The outcome of the analysis showed that satellite image data can produce satisfactory results for land usage determination.

65. Earthquakes are the result of rapid failure and release of energy resulting from strain in the lithosphere. In the face of a large break in the lithosphere various kinds of material movement, whether resulting from mechanical or physical-chemical action, will lead in the final analysis to increase in thermal energy. Therefore, surveying the variation of the ground temperature in time and space using the satellite thermal infrared waveband is a feasible, fast and relatively accurate way to detect the precursor of the impending earthquake.

66. A comparison of currently existing earthquake prediction techniques and those applied in studies of seismic monitoring and prediction reveals a unique superiority of the remote sensing technology, in that it can macroscopically monitor the dynamic evolution of the thermal anomaly on the Earth's surface and improve accuracy of earthquake prediction. Its shortcoming lies in the fact that the Advanced Very High Resolution Radiometer (AVHRR) and the Visible-Light Thermal Infrared Spin Scanning Radiometer carried by today's meteorosatelites are unable to make their observations through cloud layers, so that temperature on the ground cannot be measured. However, it is possible to estimate the temperature condition under the cloud layer by combining the analysis of the temperature value of the air on the ground at the meteorological stations with the satellite remote sensing data.

67. Airborne and satellite remote sensing techniques, such as photography, imaging radar and multispectral scanning, provide imagery of the Earth's surface which is a valuable tool for the inventory and monitoring of mountain hazard phenomena. With computer-based Geographic Information Systems (GIS) it is possible to process spatially distributed data of a geographic nature and to use information derived by digital processing and visual interpretation of remote sensing imagery. A GIS enables the analysis of the influence of a large number of terrain factors on the occurrence of mountain hazard processes.

68. The application of both currently available and future satellite remote sensing is limited, however, by its spatial resolution, which does not allow for the identification of landslide features smaller than 100 m in conditions of high contrast between the features to be mapped and the surrounding background. If contrast conditions are less favourable, identification is even more limited, to features larger than an order of magnitude of 400 m. The need for stereo imagery, which is necessary to recognize landforms in stereoscopic vision, enhances the applicability of currently available SPOT imagery.

69. Since 1976, the FAO Remote Sensing Centre, in cooperation with relevant FAO user divisions, has been actively developing and testing the operational use of data from environmental and Earth resources satellites to improve the information bases of the FAO Global Information and Early Warning System (GIEWS) on the Food and Agriculture and Desert Locust Plague Prevention Programme at international, regional and national levels.

70. The operational satellite environmental monitoring system ARTEMIS, implemented by FAO and its cooperation for real/near real-time precipitation

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and vegetation assessment in Africa, the Near East and South-West Asia, was designed and implemented based on the integrated use of high-frequency Meteosat and NOAA AVHRR data. The DIANA satellite telecommunication system will permit near real-time transmission of high-volume ARTEMIS digital data products to microcomputer-based terminals of users at both regional and national levels in Africa.

Annex

PROGRAMME OF THE WORKSHOP

<u>Date</u>	<u>Time</u>	<u>Subject</u>	<u>Speaker</u>
Monday, 23 September	9-9.45 a.m.	Opening ceremony	Y. Hui (China) C. He (ESCAP) R. Garcia (UNDP) Z. Li (China) A. Abiodun (United Nations)
	10-10.30 a.m.	<u>Keynote address</u> : Disaster risk assessment and preparedness in China	Prof. J. Ma (China)
	10.30-11 a.m.	<u>Keynote address</u> : The role of space applications in the International Decade for Natural Disaster Reduction	J. C. Scott (UNDRO)
	11-11.15 a.m.	Break	
		<u>Infrastructure: communications, remote sensing and data collection satellites</u>	
	11.15-11.45 a.m.	ERS-1 and its possible roles in disaster mitigation	Solé (ESA)
	Noon-2 p.m.	Lunch	
	2-2.45 p.m.	Plan of the World Environment and Disaster Observation Satellite System	T. Kuroda, S. Koizumi (Japan)
	2.45-3.30 p.m.	Use of INMARSAT in disaster relief operations	J. C. Bell (INMARSAT)
	3.30-3.45 p.m.	Break	
	3.45-4.30 p.m.	Satellite-based search and rescue	P. H. Pisani (France)
	4.30-5 p.m.	Practical use of satellite terminals for disaster relief operations and the establishment of such facilities at the national level	J. C. Scott (UNDRO)

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<u>Date</u>	<u>Time</u>	<u>Subject</u>	<u>Speaker</u>
		<u>Applications to disaster prevention and relief</u>	
Tuesday, 24 September	9.45 a.m.	Uses of satellite technology in disaster management	L. S. Walter (United States)
	9.45-10.30 a.m.	Applications of meteorological satellite data in weather forecasting and disaster monitoring in China	X. Xiang, C. Tian (China)
	10.30-10.45 a.m.	Break	
	10.45-11.30 a.m.	Advanced warning and evaluation of damage caused by cyclones, floods and other meteorological phenomena in Bangladesh	Md. A. Rahman, S. Begum (Bangladesh)
	11.30 a.m.- 12.15 p.m.	"Mountain hazard mapping in the Andean environment: a UNESCO-sponsored project using remote sensing imagery and the ILWIS PC-based Geographic Information System"	N. Rengers (UNESCO)
	Noon-2 p.m.	Lunch	
	2-2.45 p.m.	Drought preparedness monitoring and mapping for peninsular Malaysia	M. Baharuddin, M. Hashim (Malaysia)
	2.45-3.30 p.m.	Operational environmental satellite remote sensing for food security and locust control by FAO, the ARTEMIS and DIANA systems	J. U. Hielkema (FAO)
	3.30-3.45 p.m.	Break	
	3.45-4.30 p.m.	The flood control remote sensing information system and its applications in China	C. S. Hu (China)
	4.30-5.15 p.m.	Flood disaster and assessment at Nakhon Si Thammarat province in November 1988	C. Yusabye, S. Polngam (Thailand)
Wednesday, 25 September		<u>Visit of disaster prevention and relief facilities</u>	China
	9-11.30 a.m.	Remote Sensing Centre, Ministry of water resources	
	1.30-5 p.m.	<u>Group 1</u> Chinese Academy of Sciences: Institute of Geography, Institute of Remote Sensing Applications	

<u>Date</u>	<u>Time</u>	<u>Subject</u>	<u>Speaker</u>
Wednesday, 25 September (continued)		<u>Group 2</u> Satellite Meteorology Centre, State Meteorological Administration	
Thursday, 26 September	9-9.45 a.m.	Research on monitoring and prediction of impending earthquakes using satellite remote sensing techniques	Q. Zuji, X. Xiudeng, D. Changgong (China)
	9.45-10.15 a.m.	Regional cooperation on remote sensing technology applications to natural disaster monitoring and prevention	C. He (ESCAP)
	10.15-11 a.m.	Development of indigenous capability in space science and technology	A. A. Abiodun (United Nations)
	11 a.m.- 12.30 p.m.	Working group sessions	
	12.30-2 p.m.	Lunch	
	2-5 p.m.	Working group sessions	
Friday, 27 September	9 a.m.-Noon	Working group sessions	
	Noon-12.30 p.m.	Closing ceremony	
